Impact of Chromophores on Color Appearance in a Computational Skin Model

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MOTIVATION

- Accurate color depiction of skin lesions as well as the surrounding skin are vital in diagnostic evaluation of lesions.
- Color fidelity of skin images is a major concern for dermatologists as adoption of digital dermatoscopes is increasing rapidly.
- In creating models of skin and lesions, we need to ensure that the color representation in simulated images is highly realistic

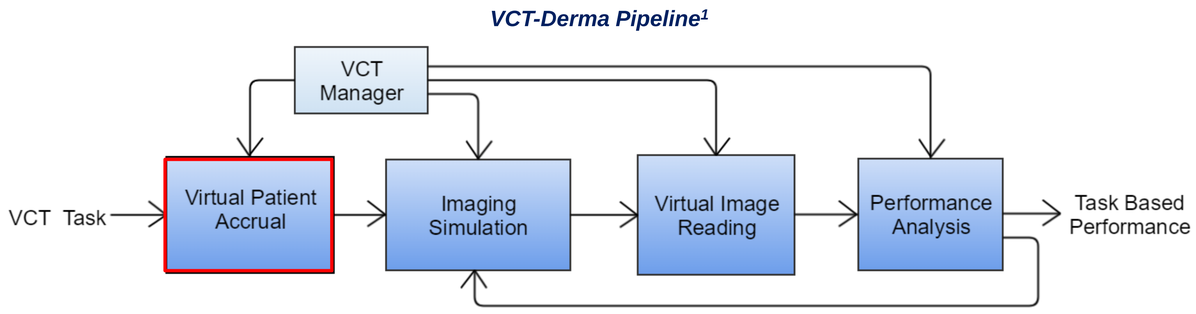
BACKGROUND

- Chromophores are light-absorbing and scattering molecules. The most important chromophore in pigmented lesions is melanin, the quantity and location of which, together with that of the blood vessels, vascular volume, etc, contribute to the colors seen under dermatoscopy.
- The presence of more than one color in a lesion is an almost sure sign of malignancy.
- Virtual clinical trials (VCTs) are a simulation-based method for validation of novel imaging systems, which reduce the cost and duration of clinical validation, provide ground truth (of simulated lesions), and allow flexible selection of system parameters to be tested.

METHODS

- We have modelled a color accurate skin simulator, with an approximation of melanoma, as part of the Virtual Patient Accrual module of the VCT-Derma pipeline[1].
- The skin models were created using open software (Blender v2.79b)[2] with the help of a physically based rendering engine called Luxcore[3].
- We have also incorporated the optical properties of some chromophores into our simulated skin model. The optical properties[4] of each layer are assumed to be uniform throughout.
- Synthetic images of a simulated lesion of diameter 1mm, were generated at various lesion positions.
- We have compared two skin models with different color representation:
  - Skin Model 1 which includes only simulated Melanin in the stratum corneum, and
  - Skin Model 2 with multiple simulated chromophores (those seen in the figure below).
- The skin model is illuminated with an ambient source of white light to better simulate natural viewing conditions.

VCT-Derma Pipeline[1]

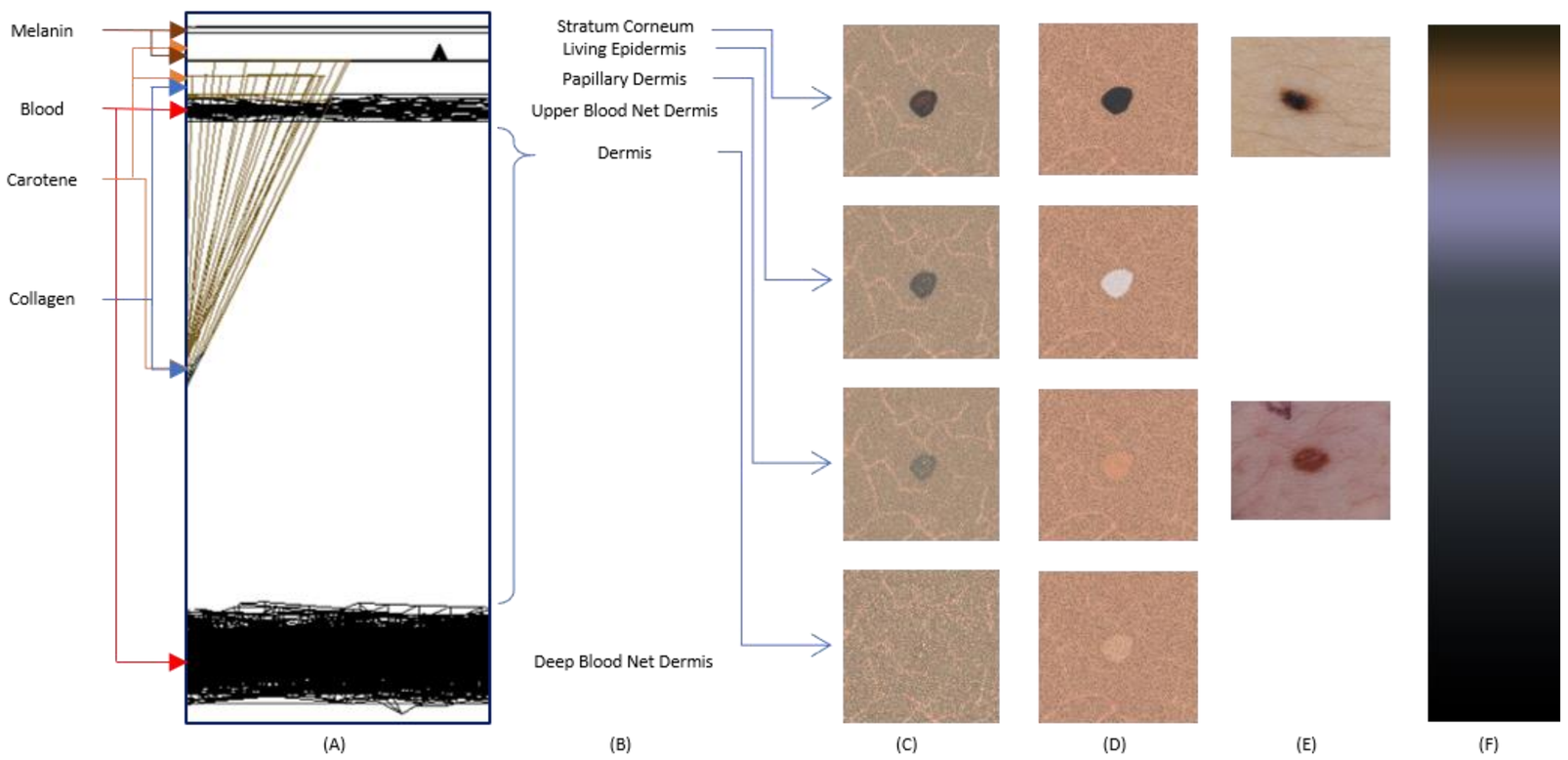


Optical Properties of skin

Skin Layer	Thickness (µm)	Scattering Coefficient (mm^{-1})	Absorption Coefficient (mm^{-1})	Absorption Depth (mm)	Anisotropy factor	Index of Refraction
Stratum Corneum	20	100	0.02	0.001	0.9	1.53
Living Epidermis	80	40	0.015	0.001	0.85	1.34
Papillary Dermis	150	30	0.07	0.001	0.8	1.4
Upper Blood Net Dermis	80	35	0.1	0.001	0.9	1.39
Dermis	1500	20	0.07	0.1	0.76	1.4
Deep Blood Net Dermis	170	35	0.1	0.001	0.95	1.39
Lesion	1000			0.1		1.7

RESULTS AND DISCUSSION

- Lesion clarity diminishes with lesion depth in both models but there is less deviation from the expected norm in the updated skin model 2 (C) as compared to the older skin model 1 (D). This is more or less in line with expectations.
- Some clinical images (E) have been obtained from literature in order to visually compare the models.
- Shown are: (A): Cross-section of the model; (B): List of simulated tissue layers; (C): The corresponding synthetic images (updated model); (D): The corresponding synthetic images (old model); (E): Sample images[5] of clinical lesions for visual comparison; and (F): The clinical lesion color variation with depth (modified from literature[5])



CONCLUSIONS

The results and preliminary visual assessment of the created synthetic images indicate clinically plausible appearance of simulated lesions. The observed lesion color suggests clinically expected variations. Future work is aimed at extending the model with other relevant dermatoscopic structures and validation of the model.

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